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THIRD PROGRESS REPORT

Contribution of Skylab multispectral imagery to the remote sensing studies of Mount Etna volcano.

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I. INTRODUCTION

The problem of the volcanic surveillance and control has been carefully considered over the last five years.

Particular effort has been made in the development of Remote Sensing Techniques due to the greater possibility they offer in the observing and quantifying of a large area in a short time.

Under this system we have two possibilities of carrying out our analysis; firstly we will consider the multispectral methods in which reflectivity characteristics of bodies are studied; secondly the thermal I.R. scanning method by which the distribution of surface temperature is analysed.

While with the multispectral method we are able to use the vegetation canopy as an indicator, with the thermal I.R. scanning system we analyse directly the energy radiated from the surface which is produced by internal volcanic activity.

There is a fundamental distinction to be made between the two methods. While with the M.S. a short delay-time can be observed between magma movement and reflectivity seepage at the vegetation canopy, with the I.R. method the delay between the cause and the thermal effect is considerably longer.

Another factor to be noted is that the I.R. method is applicable only in cases of secondary volcanic activity (fumarolas, gas vents a.s.o.) and not in the case of open chimney volcanoes.

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2. ROLES OF MULTISPECTRAL AND THERMAL I.R. SYSTEMS FOR THE VOLCANIC CONTROL AND SURVEILLANCE

The last lateral eruption of Mount Etna (February '74) offered us a new criteria for the forecasting and monitoring of these natural phenomena.

The hypothesis to be proposed consists in considering vegetation as an integrator, that is, the transfer function between the chemistry of the soil and the reflectivity of the leaves (Fig.1). In fact small but continuous amounts of magmatic gases filtering through the soil, could influence with a delay that has yet to be ascertained, the spectral behaviour of the vegetative canopy; this effect would be particularly strong in the near I.R. region.

In some cases the decrease of the reflectivity in the near I.R. region can be accompanied by a simultaneous increase of thermal I.R. radiance (Fig.2).

The data collected by the Skylab manned station during the SL3 mission about five months before the paroxismal event, was accurately analyzed.

The frames corresponding to the near I.R. band were particularly useful.

Some very interesting observations were also obtained by the analysis of the false colour image: lineaments crossing and intersecting over the area of the future eruption were discernable as well as some small circular areas where the vegetation canopy showed a reduced reflectivity. A false color composite using bands 31,32,35 was also used for the same purpose (Fig.3): a clear anomaly can be observed utilizing a strong enlargement.

These two observations are at present under investigation

by specialists; geologists, biologists, phitopathologists and, last but not least, the Remote Sensing technicians.

The multispectral analysis was followed by ground observations and by a special aerial survey. The ground-truth collection consisted primarily in observing the local geomorphology, geology and characteristics of the evergreen belt surrounding the slopes of Etna.

In July '74, four months after the eruption, an aerial survey was carried out using both 9-11 μ and 1,5-2 μ channels (Fig.4). Airborne false colour photography was also employed for the same purpose of discovering the phyto-anomalies. The path followed was that of the shape of the evergreen belt used as a geo-volcanic indicator.

It is to be noted that the evergreen belt which is formed by a fairly constant phytoassociation surrounds the slopes just at the altitude where civil disaster due to a possible eruption is impending, and the danger of lava outflows is a reality.

During the play-back phase and data processing we introduced a special kind of treatment, that of considering the ratio between the near I.R. reflected energy and the emitted one.

In fact we assumed that in an anomalous area like that of a soil affected by gas vents and covered by vegetation, the reflectivity in the near I.R. drops while the corrisponding emitted radiance increases. The ratio enphasizes these small relative fluctuation occurring between the information considered above.

Some months before, during the eruption of M.Etna of February '74 another aerial survey was carried out using a thermovision scanner mounted on board an Italian Navy helicopter.

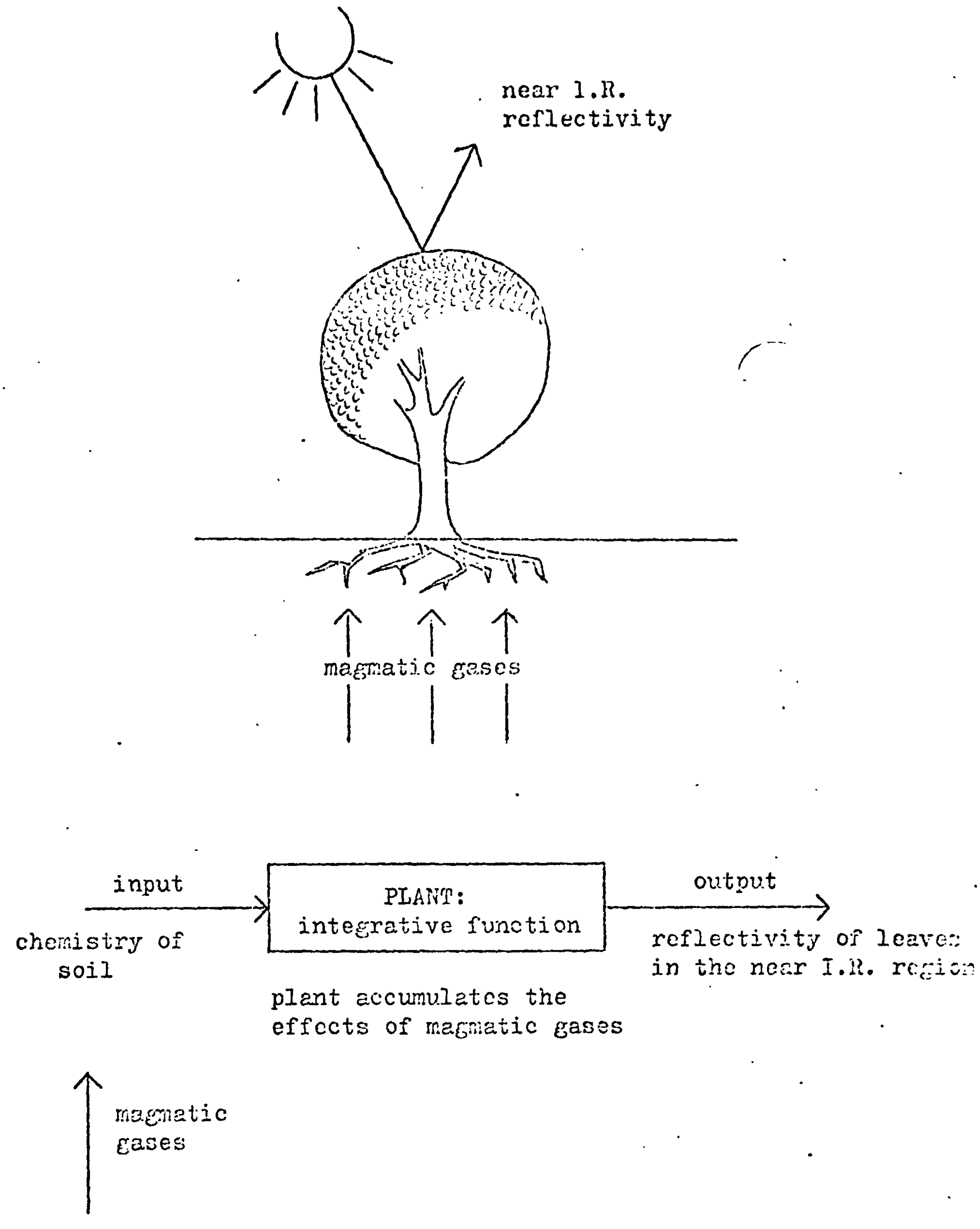
The principal task of these flights (7 flights were performed, with different light conditions) was the monitoring of possible new cleft apertures in the surroundings of the eruption. The thermal anomaly close to the lava flow outlined the reduced possibility of the forecasting of volcanic eruption using only the thermal I.R. band over an active area, such as Etna. In fact heat transfer in the volcanic material seems to be very small. The surface heat distribution is strongly related to the thermal conductivity of the layers beneath the surface and to the velocity of magma movements inside the volcanic structure.

Thermal I.R. remote sensing techniques can be considered for other types of volcanoes a new tool for mapping, describing and analyzing thermal areas, and in particular for volcanic surveillance in case of secondary volcanic activity. (See: " Remote sensing techniques applied to the study of Italian volcanic areas: the results of the repetition of the airborne I.R. survey compared to the previous data " Cassinis R, Marino C.M., Tonelli A.M.

Proceedings of : Ninth International Symposium on Remote Sensing of Environment - Ann Arbor, Michigan - April 1974).

Professor Roberto Cassinis

SEPTEMBER 25, 1974


near 1.R.
reflectivity
magmatic gases
input
chemistry of
soil
PLANT:
integrative function
output
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in the near I.R. region
plant accumulates the
effects of magmatic gases
magmatic
gases

FIG. 1

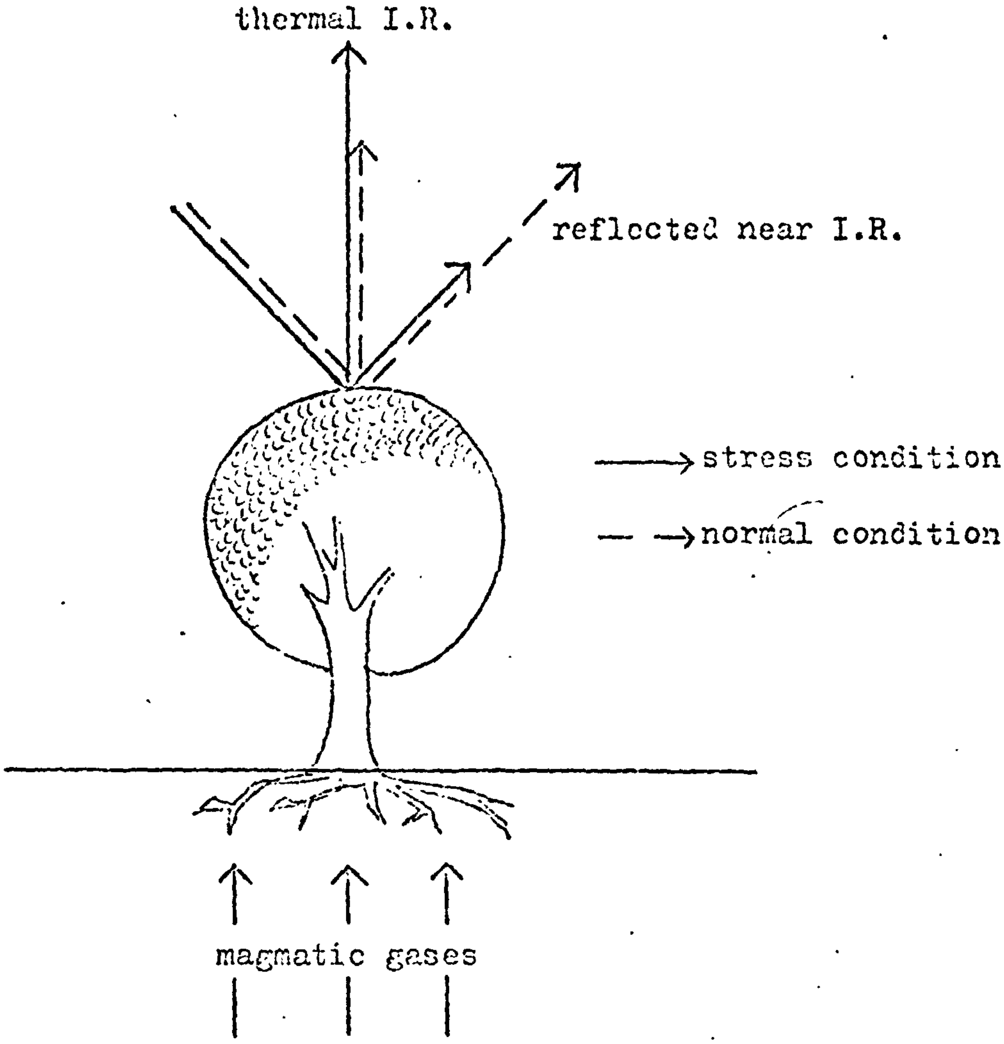
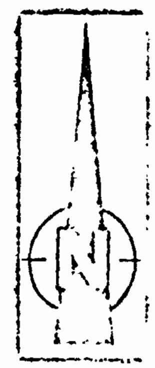
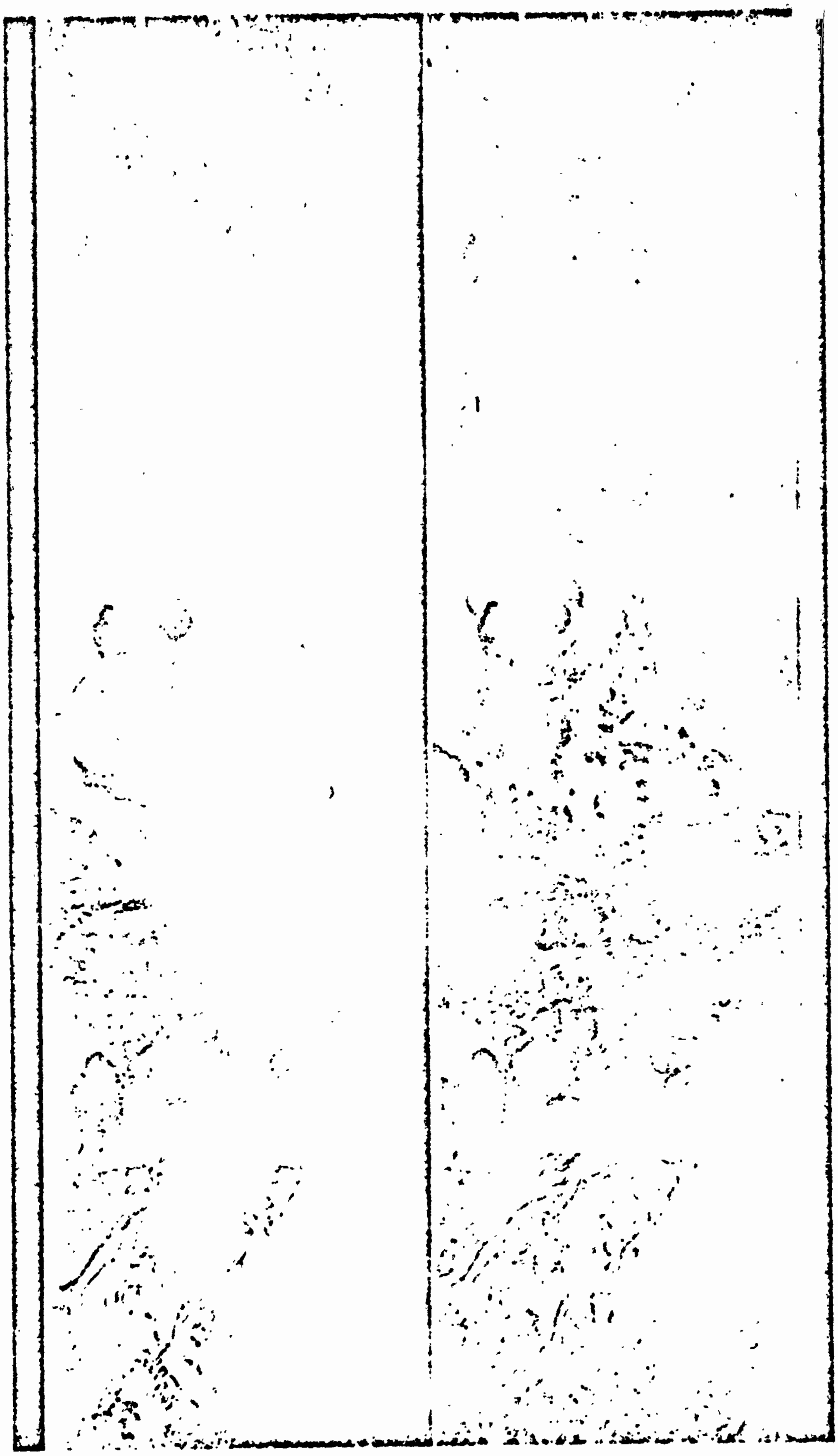

thermal I.R.
reflected near I.R.
stress condition
normal condition
magmatic gases

FIG. 2

FIG. 3





A B

FIG. 4. Thermograms of Etna volcano, in the zone of the eruption of February '74. A - near I.R. reflection (band 1,5-2 μ); B - thermal emission (band 9-11 μ).